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On the distance to the Ophiuchus star-forming region

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The Ophiuchus molecular cloud complex has produced in Lynds 1688 the richest known embedded cluster within ∼300 pc of the Sun. Unfortunately, distance estimates to the Oph complex vary by nearly ∼40% (∼120–165 pc). Here I calculate a new independent distance estimate of 135 ± 8 pc to this benchmark star-forming region based on Hipparcos trigonometric parallaxes to stars illuminating reflection nebulosity in close proximity to Lynds 1688. Combining this value with recent distance estimates from reddening studies suggests a consensus distance of 139 ± 6 pc (4% error), situating it within ∼11 pc of the centroid of the ∼5 Myr old Upper Sco OB subgroup of Sco OB2 (145 pc). The velocity vectors for Oph and Upper Sco are statistically indistinguishable within ∼1 km s^{-1} in each vector component. Both Oph and Upper Sco have negligible motion (<1 km s^{-1}) in the Galactic vertical direction with respect to the Local Standard of Rest, which is inconsistent with the young stellar groups having formed via the high velocity cloud impact scenario.

1 Introduction

The Ophiuchus cloud complex, and more specifically the Lynds 1688 dark cloud, contains the richest embedded cluster within 300 pc of the Sun (Allen et al. 2002; Lada & Lada 2003; Porras et al. 2003). Ophiuchus continues to be critical to our astrophysical understanding of many aspects of star formation and early stellar evolution (see review by Wilking, Gagne, & Allen, in press), including prestellar cloud clumps (e.g. Motte et al. 1998), the Class O protostellar stage (e.g. Andre et al. 1993), the dynamics of Class I protostars (e.g. Covey et al. 2006), substellar objects and substellar binaries (e.g. Luhman et al. 2007), the initial mass function (e.g. Luhman & Rieke 1999), and X-ray emission in T Tauri stars (e.g. Montmerle et al. 1983), among other topics.

Surprisingly the distance to the complex is not well constrained, with modern estimates from reddening studies ranging between 120–150 pc (Knude & Hog 1998), 125 ± 25 pc (de Geus et al. 1989), and 165 ± 20 pc (Chini 1981). A distance estimate to the Oph region is notably lacking from the studies of Hipparcos distances to nearby star-forming regions by Wichmann et al. (1998) and Bertout (1999). While arguments have been made that the Oph cloud is co-distant with the Upper Sco subgroup of Sco OB2 (145 ± 2 pc; de Zeeuw et al. 1999), it is possible that the group could be in front of or behind this OB subgroup. Here I estimate a distance to the Ophiuchus star-forming region via Hipparcos parallaxes to stars illuminating reflection nebulosity in the immediate vicinity of the Oph clouds. Using the improved distance and a new estimate of the mean proper motion for the Oph stellar group, I show that the motions of Oph and Upper Sco are currently indistinguishable.

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2 Analysis

2.1 Distance

I queried the Merged Catalogue of Reflection Nebulae (Magakian 2003) for nebulae within 5° in the region of the LDN 1688 cloud, with the radius chosen to generously sample much of the region where molecular gas is traced in ^{13}CO maps (Nozawa et al. 1991). I identified six reflection nebulosities with at least one bright star illuminating the structure (vdB 104, 105, 106, 107, 108, and DG 137). The clustered nature of these nebulae are obvious in Fig. 3 of Magakian (2003), and the rarity of such nebulae at high galactic latitude argue strongly for their association with the dense gas in the Oph complex (only ∼4% of the nebulae in the Magakian catalog are at Galactic latitude $b > 15°$). The Hipparcos parallaxes (Perryman et al. 1997) for the stars flagged as illuminating the nebulae (and their companions) are listed in Table 1.

I also queried the Hipparcos catalog with the list of 312 candidate members of the Oph cloud provided in the review of Wilking et al. (in press). The only Oph member with a Hipparcos parallax from the Wilking et al. list is the well-known object HIP 80462 (SR 1), which also illuminates a reflection nebula. One other object from the Wilking et al. list had a Hipparcos parallax (HIP 80685 = HD 148352), but its proper motion and parallax are very large, so I do not consider the object further in the distance calculation.

Table 1 Hipparcos parallaxes of stars associated with reflection nebulae in Oph region.

HD	HIP	Alias	Nebula	π (mas)
147165	80112	σ Sco	vdB 104	4.44 ± 0.81
147702	80377	SAO 184364	DG 137	4.73 ± 1.34
147888	80461	ρ Oph DE	vdB 106	7.33 ± 1.37
147889	80462	SR 1	vdB 105	7.36 ± 1.19
147933	80473	ρ Oph AB	vdB 106	8.27 ± 1.18
147932	80474	ρ Oph C	vdB 106	7.76 ± 0.96
148478	80763	α Sco	vdB 107	5.40 ± 1.68
148605	80815	22 Sco	vdB 108	8.30 ± 0.84

Table 2 Distance estimates to Oph.

Reference	Dist. (pc)
Chini 1981	165 ± 20 pc
de Geus, de Zeeuw & Lub 1989	125 ± 25 pc
Knude & Hog 1998	120-150 pc
This study	135^{+8}_{-7} pc
Mean	139 ± 6 pc

The eight trigonometric parallax values listed in Table 1 are consistent with a weighted mean estimate of π = 6.75 $\pm$ 0.38 mas, but with a high reduced χ^2 value (χ^2/ν = 17.7/7 = 2.5). Omitting the most deviant outlier (σ Sco) reduces the χ^2 significantly (χ^2/ν = 8.0/6 = 1.3) to a value consistent with the range of expected χ^2 for a good fit (Stuart & Ord 2005, Chapt. 16.3). Clipping the next most deviant parallax has negligible effect ($\sim$0.7σ level) on the final value. The weighted mean parallax for the remaining seven stars is π = 7.41 $\pm$ 0.43 mas, consistent with a distance of $135.0^{+8.4}_{-7.4}$ pc (6% error).

In Table 2, I compare the new distance estimate to previously published values. I combine the new estimate with the previously published independent values to derive a weighted mean distance. For Knude & Hog (1998), I assume that their range of plausible values (120–150 pc) are consistent with a normal distribution at 135 ± 15 pc. The published distances are self-consistent (χ^2/ν = 3.7/3 = 1.2), and lead to a weighted mean distance of 139 ± 6 pc (4% error). I adopt this as the best available distance to the Oph star-forming region.

2.2 Proper motion

To calculate the velocity vector of the Oph group, one also needs an estimate of the group's mean proper motion. Candidate members of the Oph cloud are generally optically faint and not well represented in the Hipparcos catalog (Perryman et al. 1997), and those that appear in the Pre-Main Sequence Stars Proper Motion Catalog (Ducourant et al. 2005) typically have large uncertainties ($\sim$10 mas yr^{-1}). The candidate Oph members are, however, sufficiently represented in astrometric catalogs of fainter stars (Tycho-2, UCAC2, SPM2.0) that one can estimate the mean proper motion of the stellar group in LDN 1688. I queried the 312 candidate Oph cloud members from Wilking et al. with entries in the Tycho-2 catalog (Høg et al. 2000, 4 matches), UCAC2 catalog (Zacharias et al. 2004, 12 matches), and SPM-2.0 catalog (Platais et al. 2007, 35 matches). The proper motions and astrometric aliases for these Oph candidate members are listed in Table 4.

Through cross-referencing entries in the UCAC2 and SPM2.0 catalogs with those in the Tycho-2 catalog (all matches within 2° of the center of the Oph stellar group), I find that UCAC2 and SPM2.0 proper motions are consistent with being on the Tycho-2 system within $<$1 mas yr^{-1} (where Tycho-2 is tied to the inertial ICRS at the $\sim$0.25 mas yr^{-1} level; Høg et al. 2000). Among the 53 stars with a counterpart in one of the astrometric catalogs, the proper motion with the smallest uncertainty was selected. Calculation of the mean proper motion (and its uncertainty) for the group were made using three estimators which are fairly insensitive to outlying points, including the true median (Gott et al. 2001) and the clipped mean using Chauvenet's criterion (Bevington & Robinson 1992). The proper motions were also run through a custom-made clipping routine which iteratively clips the most discrepant outliers until a mean value is found that gives a χ^2 sufficiently low to be considered a good fit considering the degrees of freedom (Stuart & Ord 2005). For the clipping routine, an internal velocity dispersion of 1.5 mas yr^{-1} was assumed, appropriate for 1 km s^{-1} (typical for young clusters) at d = 139 pc. I justify the clipping of the data outliers on the grounds that our parent sample may contain interlopers unrelated to the Oph cloud (e.g. HD 148352) and probable cloud members whose motions are likely perturbed due to binarity (e.g. SR 1). The three estimators converge on a mean proper motion of ($\mu_{\alpha\cos\delta}, \mu_\delta$ = –10, –27 mas yr^{-1}). The statistical error in each component of this estimate is $\sim$1.5 mas yr^{-1}, and the estimated systematic errors are $\sim$1 mas yr^{-1} (for the UCAC2 and SPM catalogs, on which this analysis is heavily dependent), so I conservatively assign a total uncertainty in the mean proper motion of 2 mas yr^{-1}. The mean proper motion of the Oph cloud members is remarkably close to the median value for 120 members of the adjacent Upper Sco group: ($\mu_{\alpha\cos\delta}, \mu_\delta$ = –11, –24 mas yr^{-1}, de Zeeuw et al. 1999).

An investigation of the kinematics of individual candidate group members is beyond the focus of this study, but one should note that some Oph candidates have large proper motions clearly inconsistent with group membership (especially HD 148352, [GY92] 165, and [GY92] 280). The Hipparcos astrometry and photometry of the high proper motion star HD 148352 are consistent with it being an unreddened foreground F dwarf, unrelated to the Oph cloud. The 2MASS and SPM photometry of the high proper motion star [GY92] 165 are consistent with it being an unreddened foreground late-K dwarf, rather than a member of the Oph cloud. The high proper motion star [GY92] 280 has 2MASS photometry consistent with an unreddened early-M dwarf.

Indeed Wilking et al. (2005) classify the star as an M2 "dwarf?" and Strom et al. (1995) classify it as "foreground", so we confirm its interloper status based on its proper motion. Neither [GY92] 165 & 280 have been detected in deep X-ray images, again supporting their status as old interlopers. All three should be rejected from Oph membership lists. Two stars with accurate proper motions that were consistently clipped (SR 2 & 9) are likely to be bona fide Oph members whose photocentric motion is perturbed by their binarity.

2.3 Space velocity and position

I calculate the Galactic space motion vector for the members of the Oph cloud using the best estimate of the distance (139 $\pm$ 6 pc), proper motion ($\mu_{\alpha\cos\delta}, \mu_\delta$ = –10 $\pm$ 2, –27 $\pm$ 2 mas yr^{-1}), the median position of the Wilking et al. cloud members (α, δ = 246.78°, –24.48°), and the median RV for Oph pre-MS stars (–6.3 $\pm$ 0.3 km s^{-1} Prato 2007; Guenther et al. 2007; Kurosawa, Harris & Littlefair 2007; James et al. 2006). The Galactic space motion vector (velocities with respect to the Sun, no correction for Galactic rotation) is (U, V, W = –6.2, –17.1, –8.3 km s^{-1}) with errors in the velocity components of (1.0, 1.3, 1.3 km s^{-1}). Given that the Sun's peculiar motion in the Z direction with respect to the Local Standard of Rest (LSR) is +7.2 $\pm$ 0.4 km s^{-1} (Dehnen & Binney 1998), I find that Oph is statistically consistent with having negligible vertical motion with respect to the LSR (ΔW = –1.2 $\pm$ 1.3 km s^{-1}).

From Monte Carlo simulations that sample the uncertainties in the best estimates for the distances and centroid positions for Oph and the Upper Sco OB subgroup of Sco OB2 (145 pc; de Zeeuw et al. 1999), I find that the group centroids are only 11 $\pm$ 3 pc in separation, with Oph slightly in the foreground. The centroid position of the Oph cloud population, in Galactic coordinates (X towards Galactic center, Y in direction of Galactic rotation, Z towards the North Galactic Pole) is (X, Y, Z = 132, –16, 40 pc). The median position of the Upper Sco population (de Zeeuw et al. 1999) is (X, Y, Z = 135, –21, +49 pc). The properties of the Oph stellar group are summarized in Table 3. The relative positions agree with de Geus's (1992) picture where the ρ Oph cloud is situated in the foreground of the slightly more distant Upper Sco OB subgroup.

The massive stars in Upper Sco have often been cited as the agent responsible for triggering the star-formation in the Oph cloud (e.g. de Geus 1992; Preibisch et al. 2002), so it is of interest to models of triggered star-formation what the bulk velocity of the Oph cloud membership is with respect to the Upper Sco subgroup. Although the Upper Sco subgroup is well-studied, surprisingly there is an uncomfortably large range of Galactic space motion velocity estimates in the recent literature (de Zeeuw et al. 1999; de Bruijne 1999; Madsen et al. 2002). Thus far the velocity estimates of the centroid motion for Upper Sco are critically dependent on the location of the convergent point and the tangential velocity for estimating the Galactic velocity components. However, for an *expanding* subgroup, the convergent point analysis will give the velocity of a group member participating in the linear expansion at the position of the Sun (e.g. Brown et al. 1997; Mamajek 2005), which is not the quantity that interests us here. That the published velocity vectors for the Sco-Cen subgroups inferred from convergent point analysis alone (i.e. ignoring radial velocity data; e.g. Madsen et al. 2002) are probably in error is demonstrated by the fact that the vectors predict radial velocities that are systematically off of the mean observed RV by several km s^{-1}. Including an estimate of the group radial velocity in the analysis gives a more accurate estimate of a group's bulk motion, independent of the effects of any expansion. To estimate the bulk motion of Upper Sco I calculate the velocity vector using the median position, distance, proper motion, and radial velocity for the 120 Upper Sco members from de Zeeuw et al. (1999). This leads to a space velocity of (U, V, W = –5.2, –16.6, –7.3 km s^{-1}), with component errors of only $\sim$0.3 km s^{-1}. As with Oph, Upper Sco demonstrates negligible motion in the vertical direction with respect to the LSR (ΔW = –0.1 $\pm$ 0.5 km s^{-1}). Their relative motion (in the sense Oph minus Upper Sco) is then (ΔU, ΔV, ΔW) = (–1.0, –0.6, –1.1) $\pm$ (1.0, 1.3, 1.3) km s^{-1}. Hence, Oph is moving at a negligible 1.6 $\pm$ 2.1 km s^{-1} with respect to the Upper Sco population. *These results show that the velocities of Oph and Upper Sco are statistically indistinguishable at the $\sim$km s^{-1} level, and that both groups have negligible vertical motion with respect to the LSR*.

Table 3 Properties of the Lynds 1688 group.

Property	Value
Distance	139 $\pm$ 6 pc
Distance Modulus	5.72 $\pm$ 0.09 mag
$\overline{\mu_{\alpha\cos\delta}}$	–10 $\pm$ 2 mas yr^{-1}
$\overline{\mu_\delta}$	–27 $\pm$ 2 mas yr^{-1}
Radial Velocity	–6.3 $\pm$ 0.3 km s^{-1}
Position (ICRS)	246.°78, –24.°48
Position (Galactic)	353.°11, +16.°74
Position (X, Y, Z)	132, –16, 40 pc
Velocity (U, V, W)	–6.2, –17.1, –8.3 km s^{-1}

3 Discussion

Our independent distance to Oph (135 $\pm$ 8 pc) is comfortably within the range of previous distance estimates (120–166 pc). The distance to Oph is very similar to that of other star-forming clouds in its vicinity, including the neighboring Pipe Nebula $\sim$35 pc to the east (d = 130^{+13}_{-20} pc, Lombardi et al. 2006), the Lupus cloud complex $\sim$35 pc to the west (d = 140 $\pm$ 20 pc; Hughes et al. 1993), and the Corona Australis complex $\sim$80 pc to the south (d = 129 $\pm$ 11 pc; Casey et al. 1998). These clouds are also in close proximity to the Upper Sco and Upper Cen-Lup OB subgroups (both at $d \simeq$ 140 pc,

Table 4 Proper motions of candidate Oph members.

Name	Astrometric Alias	$\mu_{\alpha\cos\delta}$ (mas yr^{-1})	μ_δ (mas yr^{-1})
BKLT J162643-241112*	U 22028257	–8.2 ± 7.8	–23.2 ± 5.0
DoAr 21*	S 57602749	–20.5 ± 3.6	–21.0 ± 3.6
DoAr 24*	S 57602752	–7.6 ± 3.6	–26.3 ± 3.7
DoAr 24E*	S 57602750	–6.8 ± 3.7	–29.4 ± 3.8
DoAr 25	U 21797656	–10.4 ± 5.0	–23.2 ± 5.0
DoAr 25*	S 57602745	–12.9 ± 3.6	–27.4 ± 3.6
DoAR 32*	S 57603012	–5.8 ± 4.2	–22.9 ± 4.2
DoAR 33*	S 57603011	–9.1 ± 3.8	–27.2 ± 3.8
HD 148352	S 57603135	–52.6 ± 3.3	–64.7 ± 3.4
HD 148352	T 6799 930 1	–49.9 ± 1.5	–63.1 ± 1.5
HD 148352*	H 80685	–52.3 ± 0.9	–64.2 ± 0.7
ROX 2*	S 57602512	–10.5 ± 5.3	–37.9 ± 5.3
ROX 3*	S 57602744	–13.0 ± 5.9	–28.0 ± 6.1
ROX 4*	S 57602746	–5.6 ± 4.7	–18.7 ± 4.7
ROX 7*	S 57602748	–33.0 ± 6.9	–13.0 ± 6.9
ROX 16*	S 57602906	–17.1 ± 6.0	–26.6 ± 6.0
ROX 31	S 57603002	–9.9 ± 7.0	–27.5 ± 7.0
ROX 31*	U 21797684	–12.0 ± 5.3	–17.1 ± 5.3
RX J1624.9-2459*	U 21797634	–10.2 ± 5.3	–1.9 ± 5.5
SR 1	H 80462	–2.3 ± 1.4	–25.5 ± 1.0
SR 1	S 57602509	–3.1 ± 3.5	–27.0 ± 3.5
SR 1*	T 6798 539 1	–1.4 ± 0.9	–25.0 ± 1.0
SR 2	S 57602510	–18.5 ± 3.1	–25.2 ± 3.3
SR 2	T 6798 544 1	–20.2 ± 2.4	–27.4 ± 2.2
SR 2*	U 22028253	–20.5 ± 1.9	–26.2 ± 1.4
SR 3	U 21797645	–9.7 ± 9.8	–33.9 ± 5.3
SR 3*	S 57602747	–14.3 ± 3.8	–29.0 ± 3.6
SR 4	S 57602751	–14.5 ± 6.3	–27.8 ± 6.3
SR 4*	U 22028255	–14.1 ± 5.1	–17.7 ± 5.0
SR 8*	S 57602506	–7.5 ± 3.6	–26.7 ± 3.6
SR 9	S 57603009	–13.3 ± 3.3	–30.6 ± 3.7
SR 9	T 6794 513 1	–10.5 ± 3.2	–32.3 ± 3.0
SR 9*	U 22028258	–15.5 ± 1.5	–33.5 ± 1.5
SR 10*	S 57603007	–9.0 ± 3.6	–26.6 ± 3.7
SR 12*	S 57603001	–9.8 ± 7.5	–30.8 ± 6.0
SR 13*	S 57603136	–9.6 ± 3.6	–28.5 ± 3.6
SR 20*	S 57603138	–8.2 ± 3.7	–27.8 ± 3.7
SR 21*	S 57602905	–7.3 ± 3.6	–33.0 ± 3.7
SR 22	S 57602508	–10.4 ± 6.1	–24.0 ± 6.1
SR 22*	U 22028254	–5.2 ± 5.5	–25.4 ± 5.0
SR 24*	S 57602902	–4.9 ± 6.2	–23.4 ± 6.2
WSB 28*	S 57602753	–18.5 ± 7.2	–22.9 ± 7.2
WSB 40*	S 57602907	–21.5 ± 6.8	–19.5 ± 6.8
WSB 45*	S 57602897	–0.5 ± 7.0	–36.8 ± 7.0
WSB 46	U 21797671	–12.0 ± 5.3	–25.1 ± 5.0
WSB 46*	S 57602896	–12.6 ± 4.4	–30.8 ± 4.4
WSB 48*	S 57602997	–11.2 ± 6.8	–31.4 ± 6.8
WSB 49*	U 21797676	–7.7 ± 5.2	–22.0 ± 5.1
[GY92] 112	S 57602904	–3.3 ± 7.6	–42.2 ± 7.6
[GY92] 112*	U 21797666	1.9 ± 5.2	–18.3 ± 5.0
[GY92] 165*	S 57602901	51.8 ± 3.6	–60.9 ± 3.6
[GY92] 280*	S 57603003	78.3 ± 7.3	–56.8 ± 7.3
[GY92] 372*	S 57603008	–8.5 ± 4.4	–31.4 ± 4.4

Notes: "*" flags the proper motion with smallest uncertainty for each star. "H" is HIP, "U" is UCAC2, "S" is SPM2.0, "T" is Tycho-2. "SR" appears in SIMBAD as "Em* SR".

with ages $\sim$5 and $\sim$15 Myr, respectively), suggesting that these star-forming clouds and the Sco-Cen OB association formed from the same large-scale process.

The similarity in velocities between the $\sim$5 Myr Upper Sco members and the newly formed Oph members suggests that Upper Sco and Oph formed from gas with roughly the same bulk motion. The kinematic data can be used to discount the high velocity cloud (HVC) impact model for forming Ophiuchus. Lepine & Duvert (1994) proposed that the Oph cloud (and the entire Sco-Cen complex) was formed as the result of a HVC impact, where the progenitor HVC impacted the Galactic plane at $\sim$250 km s^{-1}. In order to explain the distribution of positions and ages of young stars in the Oph-Sco-Cen region, the Oph cloud (representing the dense, shocked layer in the collision) was predicted to be falling towards the Galactic plane from a maximum height of $Z \simeq$ +100 pc (where it would have negligible vertical motion). However, both Oph and Upper Sco appear to have negligible motion in the Z direction with respect to the LSR at their current locations. The scenario also predicts that the velocities of young stars formed in the HVC impact should have significantly different velocities as the shocked layer is decelerated and the motions of the newly-formed stars are dominated by the Galactic potential rather than the motions of the gas. The similarity of the vertical motions of Oph and Upper Sco (within $\sim$1 km s^{-1} of each other and the LSR) appear to also be inconsistent with this prediction.

The kinematic data and star-formation history of the Oph and Upper Sco region give us some clue regarding the nature of the two older ($\sim$15 Myr), and more distended Sco-Cen subgroups: Upper Cen-Lup (UCL) and Lower Cen-Cru (LCC). Although larger and older than Upper Sco, UCL and LCC have similar velocity dispersions as Upper Sco ($\sim$1 km s^{-1}, de Bruijne 1999; Mamajek, Meyer & Liebert 2002). Despite the km s^{-1}-level coherence in the motions of its members, LCC shows some evidence of an age spread with the northern part of the group having mean age $\sim$17 Myr, while the southern part (the Southern Cross) has mean age $\sim$12 Myr (Preibisch & Mamajek, in press). One can imagine that Upper Sco ($\sim$5 Myr age) and Oph ($<$2 Myr) may evolve into a LCC-like configuration in $\sim$10 Myr time, after the newly formed massive stars have cleared the Oph region of its star-forming molecular gas. If the Oph young stellar population is unbound after its molecular gas is dispersed, then a future observer of the Sco-Oph region (say $\sim$10 Myr in the future) with kinematic information of $\sim$km s^{-1} accuracy would have difficulty disentangling the members of Oph and Upper Sco by any kinematic criteria. Following our observations of the Oph and Upper Sco regions, it seems possible that UCL and LCC are each comprised of the unbound remnants of multiple embedded clusters with similar bulk motions (within $\sim$1 km s^{-1}) that formed over a $<$10 Myr span, rather than the remnants of two large embedded clusters that formed in single bursts.

The Oph cloud is being impacted by the Upper Sco bubble of atomic hydrogen and molecular gas, presumably the remnants of the proto-Upper Sco molecular cloud (de Geus 1992). If one hypothesizes that Oph represents a long-lived remnant clump of the proto-Upper Sco cloud, then it has apparently inherited $<$2 km s^{-1} of relative velocity from the expansion of the Upper Sco bubble. The kinematic data are also inconsistent with the idea that the Upper Sco stars formed from the *contemporary* Oph clouds, and "migrated" to their current positions. The data are consistent with the idea that the Oph cloud complex and Upper Sco proto-cloud formed from the same large scale process, which endowed them with similar velocities and positions in close proximity ($\sim$10 pc), but that conditions for star-formation in Upper Sco were ripe (and then soon extinguished) $\sim$5 Myr before that in Oph.

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4 Note Added In Proof

Floor van Leeuwen (2007, *Hipparcos, the New Reduction of the Raw Data*, Springer) has recently published revised trigonometric parallaxes from the Hipparcos data for the stars in Table 1. Repeating the calculation in §2.1 using the new parallaxes results in a mean parallax of π = 7.62 $\pm$ 0.15 mas (131 $\pm$ 3 pc ; distance modulus = 5.59 $\pm$ 0.04 mag). Rejecting σ Sco (HIP 80112) again improves the solution from χ^2/ν = 32.3/7 to 6.7/6 (= 1.1). The revised distance of 131 $\pm$ 3 pc (2% error) is probably the best available derived from Hipparcos data. The revised mean velocity vector for the Oph group is (U, V, W = –6.2, –16.1, –8.0 km s^{-1}) with errors in the velocity components of (0.9, 1.1, 1.2 km s^{-1}). This makes its relative motion with respect to Upper Sco slightly smaller (1.3 $\pm$ 1.9 km s^{-1}). The slight shift in distance has negligible impact on both the quantitative and qualitative conclusions of this study.

